

# PREDICTIONS FROM NEW PHYSICS MODELS FOR $\nu$ PRODUCTION

Patrick Meade  
Yang Institute for Theoretical Physics  
Stony Brook University

Based on:

**D. Curtin, P. Jaiswal, PM 1206.6888**  
**D. Curtin, P. Jaiswal, PM, P. Tien 1304.7011**  
**D. Curtin, PM, P. Tien 1406.0848**  
**PM, H. Ramani, M. Zeng 1407.4481**

# PREDICTIONS FROM NEW PHYSICS MODELS FOR $W$ PRODUCTION

**+discussion  
of SM effects  
in  $WW$**

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WHERE'S THE NEW PHYSICS  
AND WHY ON EARTH  
SHOULD IT BE IN VV?

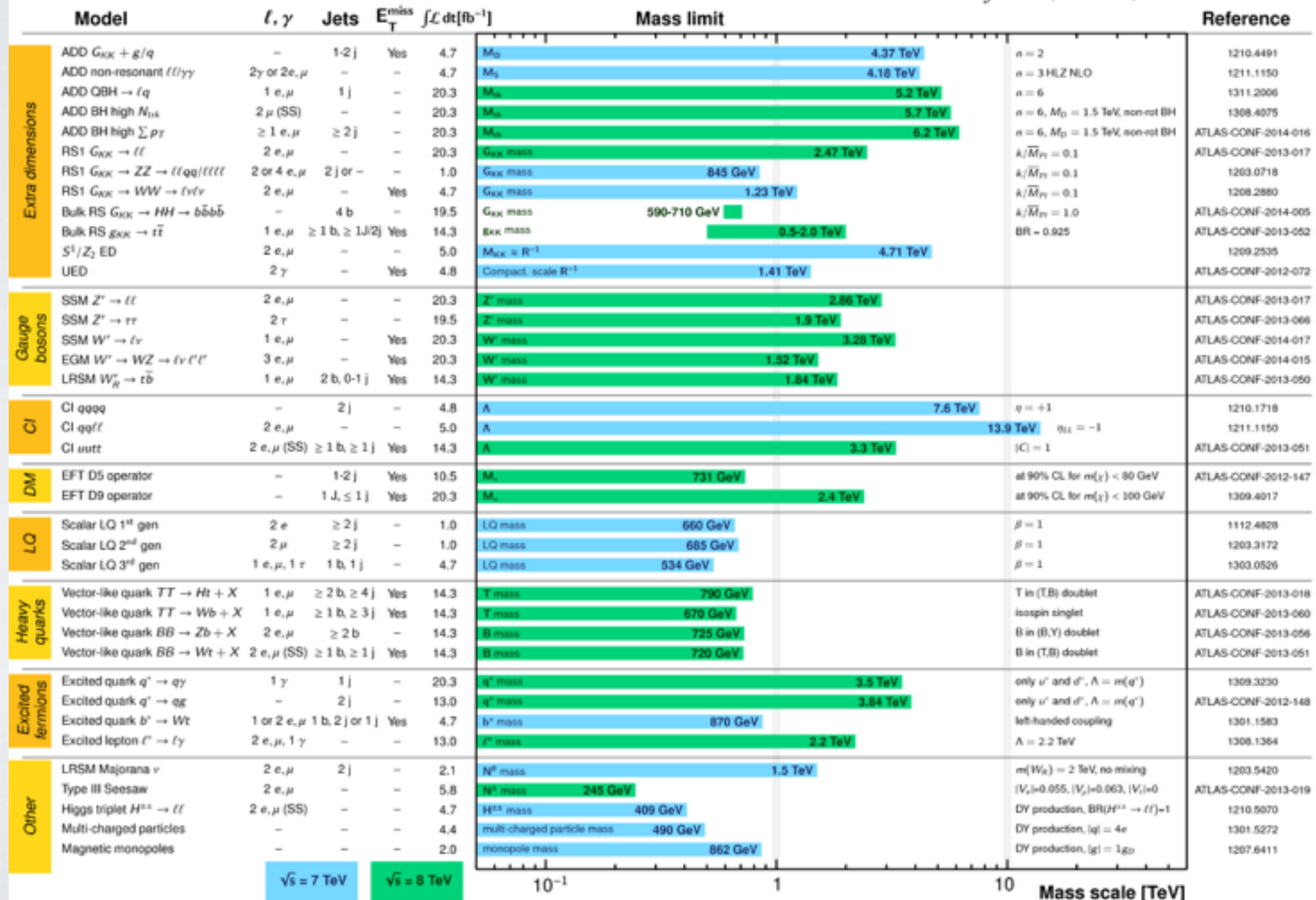
# NO NEW PHYSICS ANYWHERE?

## ATLAS Exotics Searches\* - 95% CL Exclusion

Status: April 2014

ATLAS Preliminary

$\int \mathcal{L} dt = (1.0 - 20.3) \text{ fb}^{-1}$   $\sqrt{s} = 7, 8 \text{ TeV}$



\*Only a selection of the available mass limits on new states or phenomena is shown.



# WHERE TO LOOK?





# WHERE TO LOOK?





# WHERE TO LOOK?

*Anything closer?*

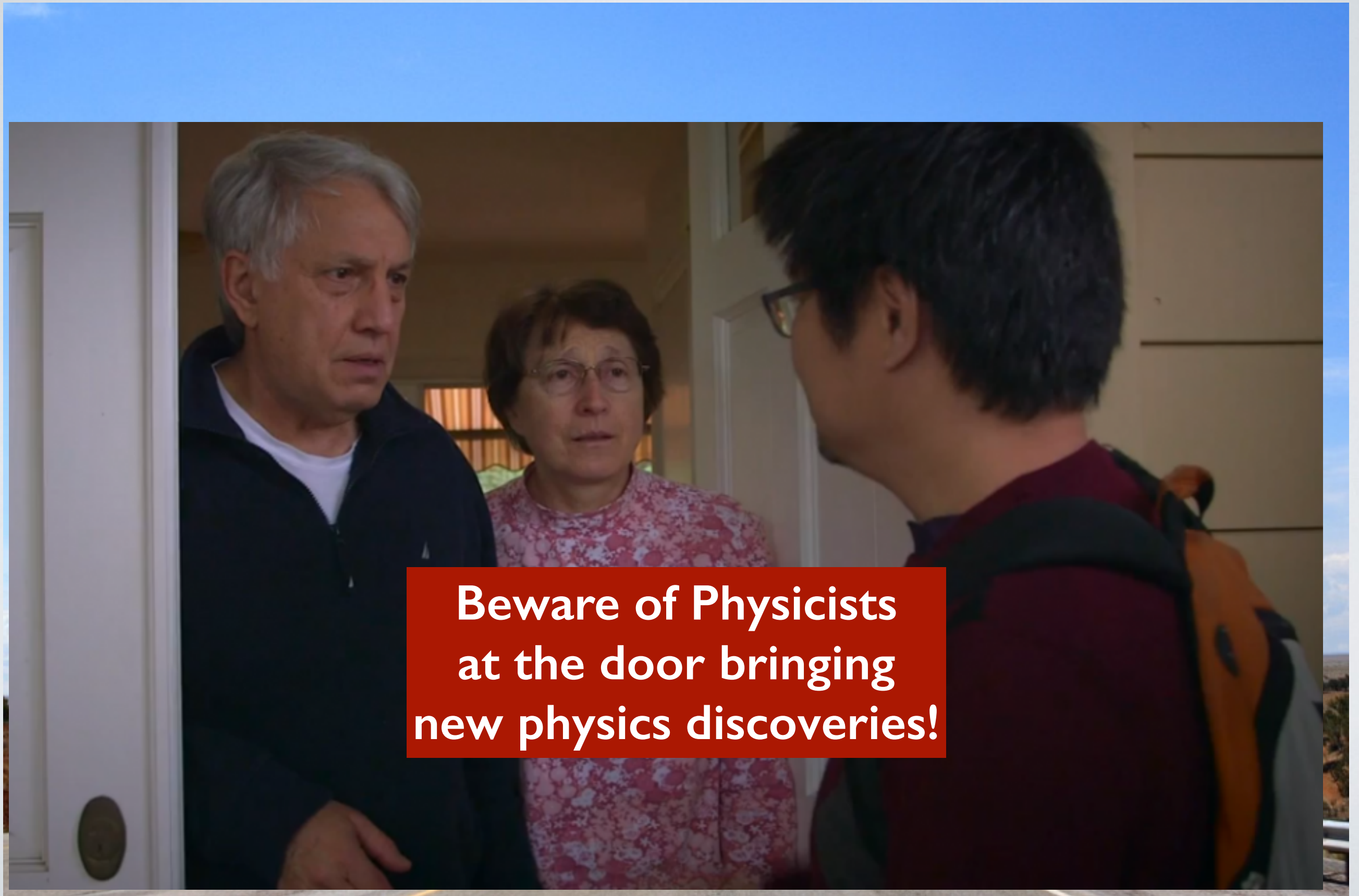


# WHERE TO LOOK?





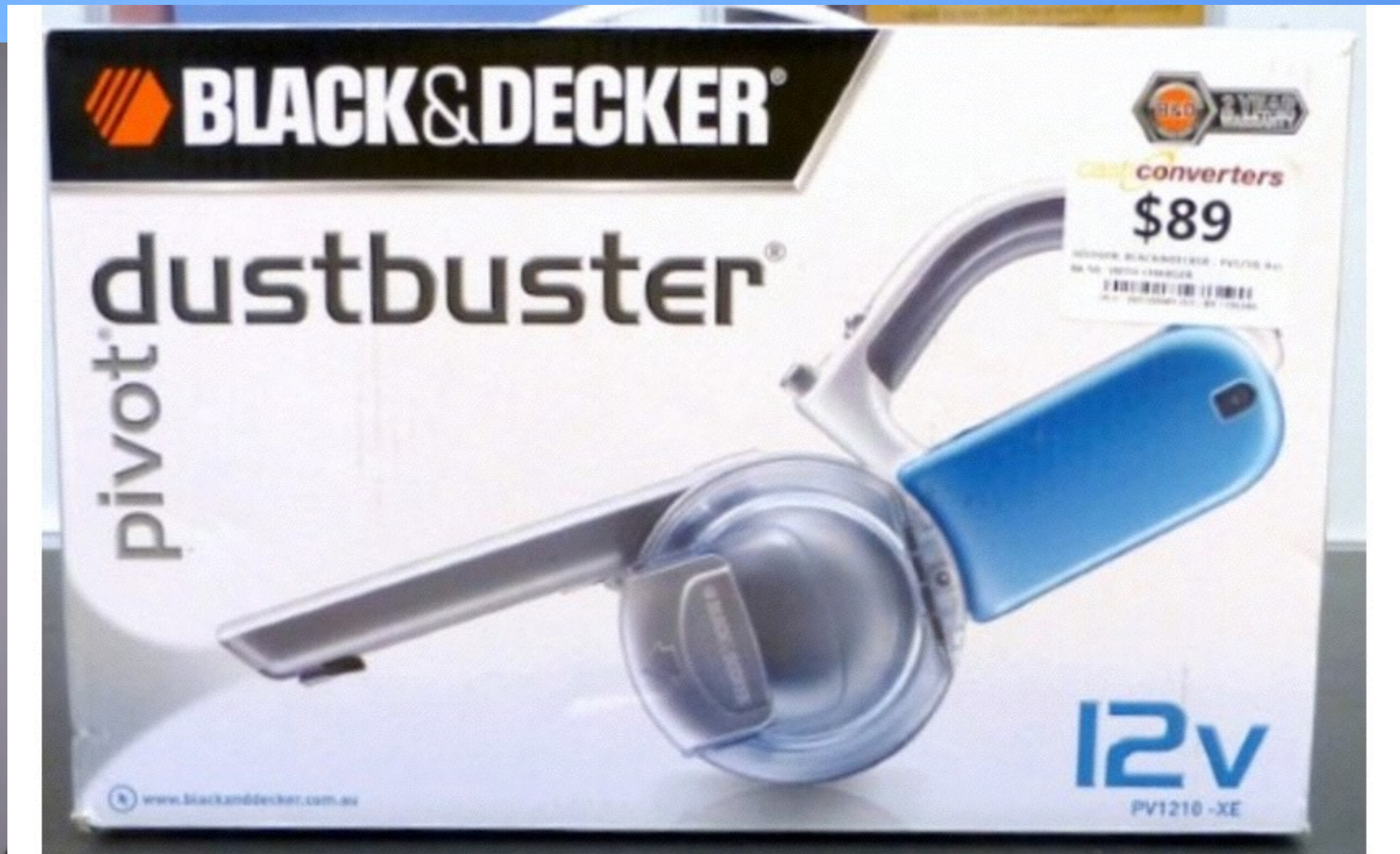
# WHERE TO LOOK?



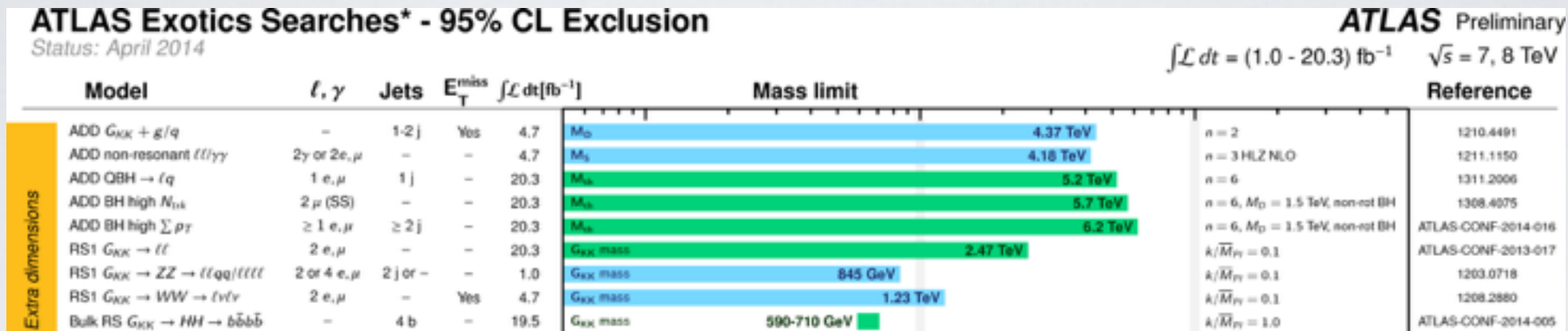
**Beware of Physicists  
at the door bringing  
new physics discoveries!**



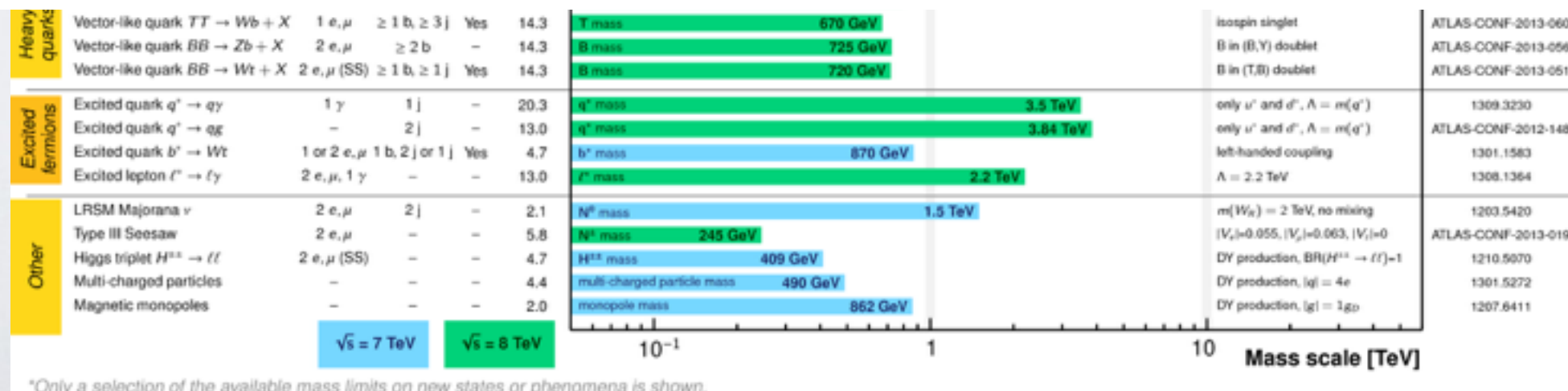
# WHERE TO LOOK?



# NO NEW PHYSICS AT THE LHC



It must be at higher mass scales!!!





LET'S MAKE SURE NOT TO  
LEAVE ANY SCALE BEHIND!





# THE ONLY NEW PHYSICS WE'VE FOUND SO FAR IS THE HIGGS

Is there anything else lurking at the EW scale?  
(remember the CDF  $Wjj$  saga...)

It's difficult to go after this scale... Contrary to deep ingrained desire of BSM experimentalists not to trust theorists and do everything in a “data-driven” manner



# DATA-DRIVEN SEARCHES...



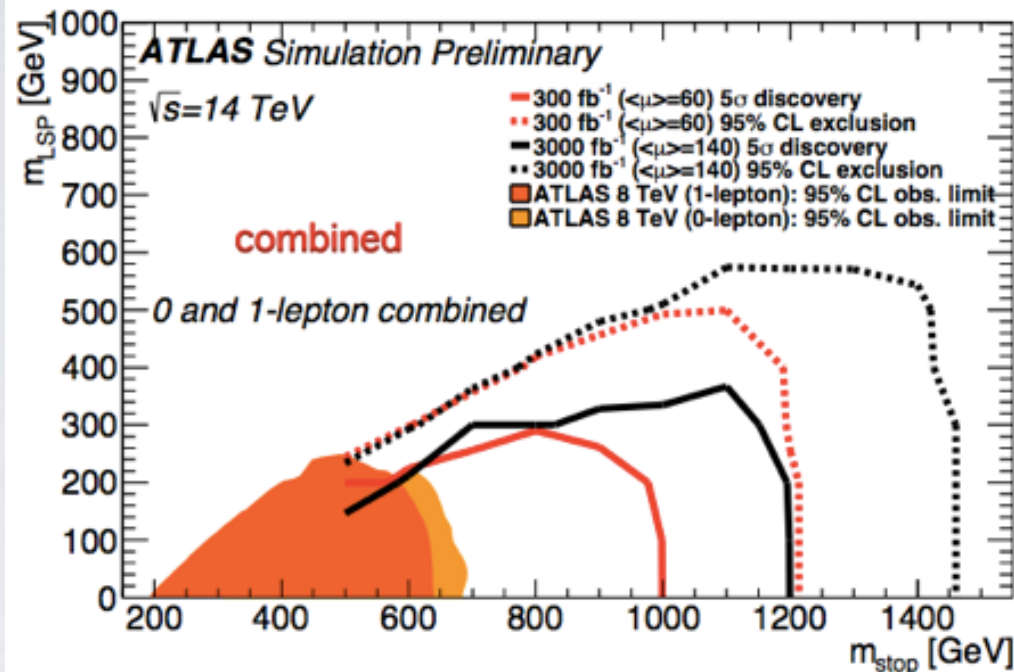


# Michelangelo Mangano @ FNAL

## Next Steps in the Energy Frontier August 2014

### Example: LHC vs HL-LHC

Direct stop searches (Altan Cakir, this wshop)



$Z' \rightarrow e^+e^-$

ATLAS/CMS HL docs	300/fb	3000/fb
95% excl (ATLAS)	<b>6.5 TeV</b>	7.8 TeV
5 $\sigma$ (CMS)	5.1 TeV	<b>6.2 TeV</b>

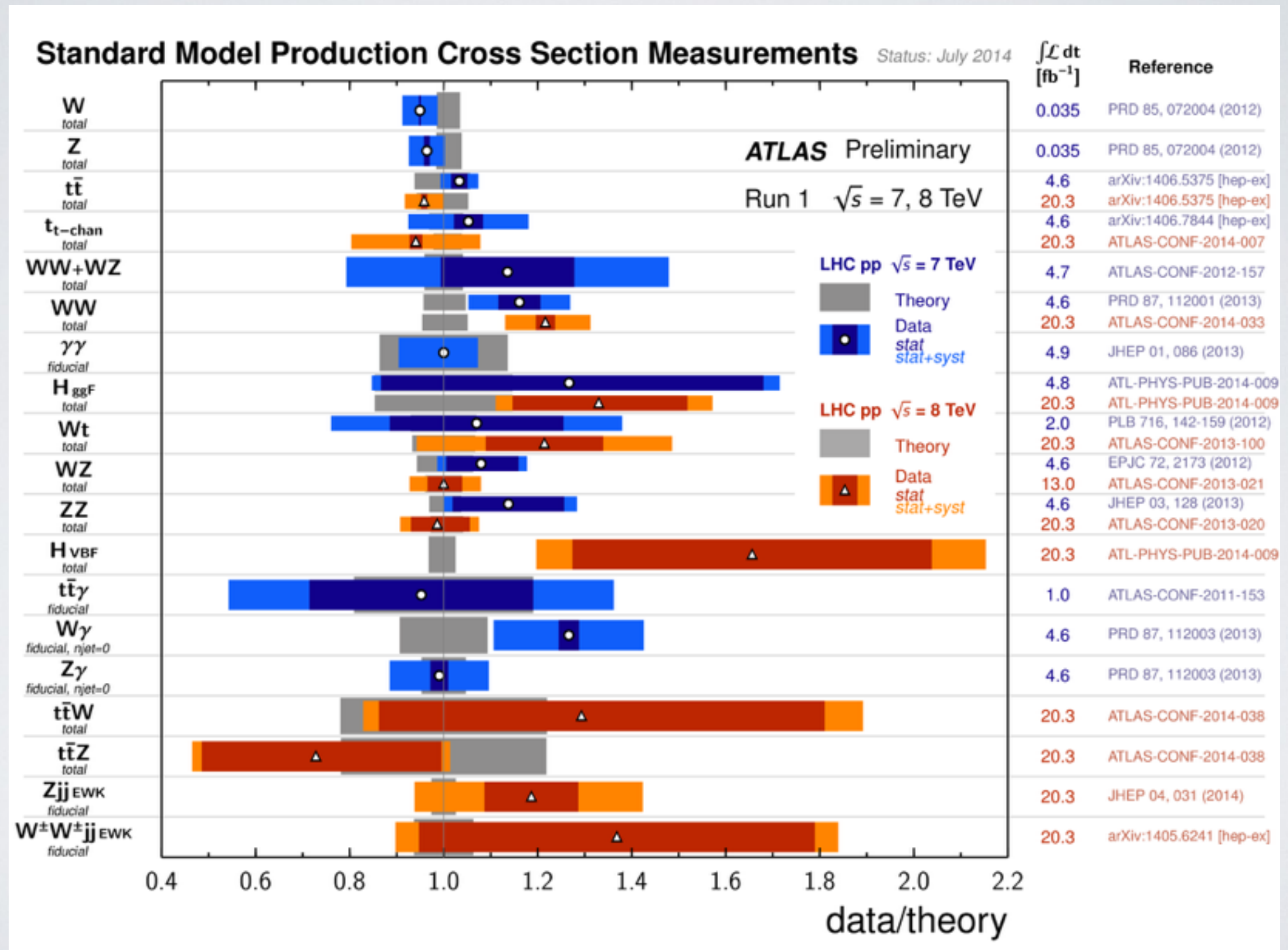
### Message:

- What's been excluded at Lum will not be discovered at 10 x Lum, unless ...
  - At high mass there is ~nothing to do (eff and accept are ~ 1)
  - At low mass (eff, accept  $\ll$  1, elusive signals) one could invest in improved detector/trigger performance, to boost useful rates and sensitivity by factors larger than L increase

LET'S LOOK AT AN  
EXAMPLE ALREADY  
PROVIDED BY THE LHC!



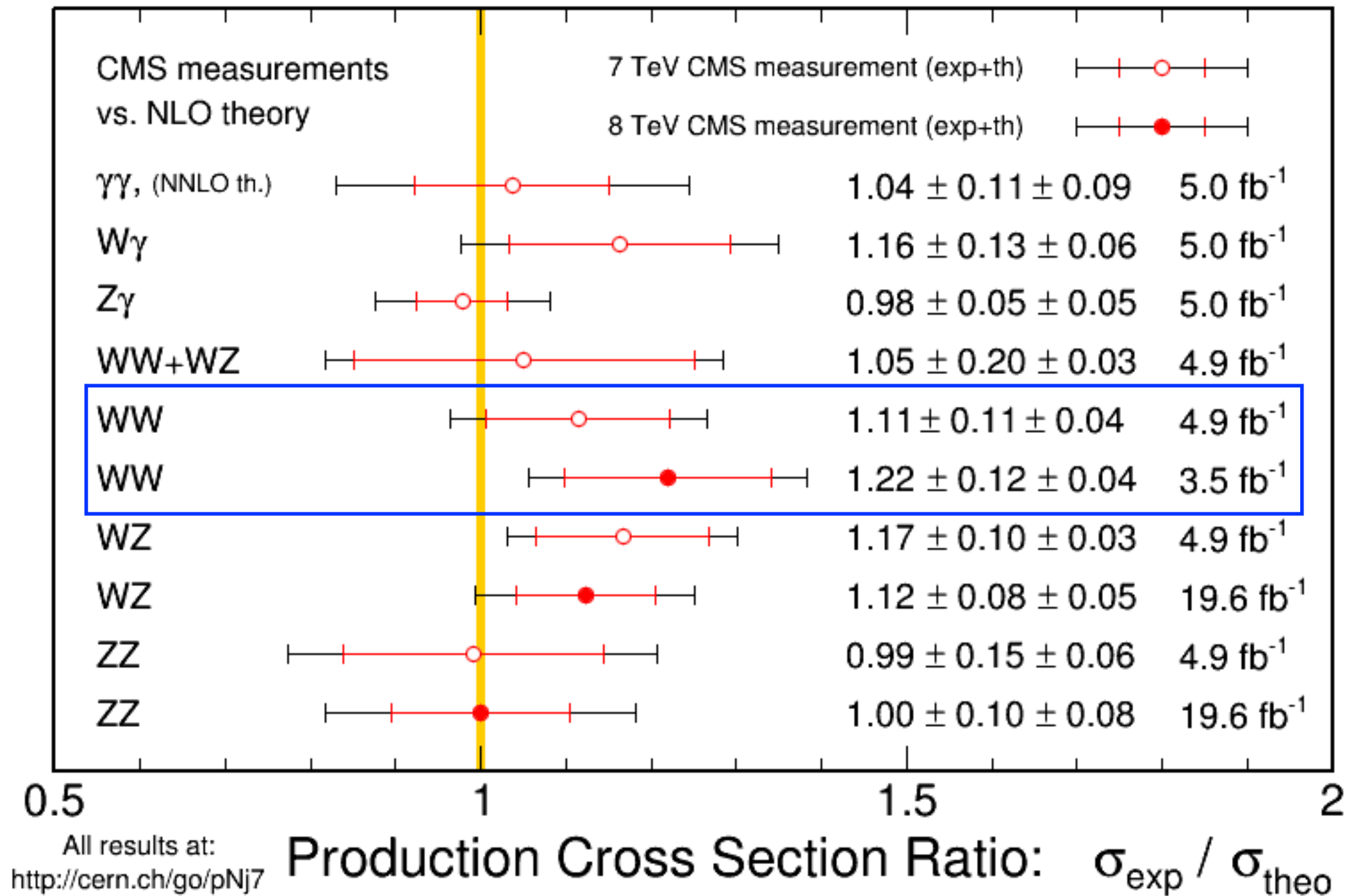
# WW CROSS SECTION



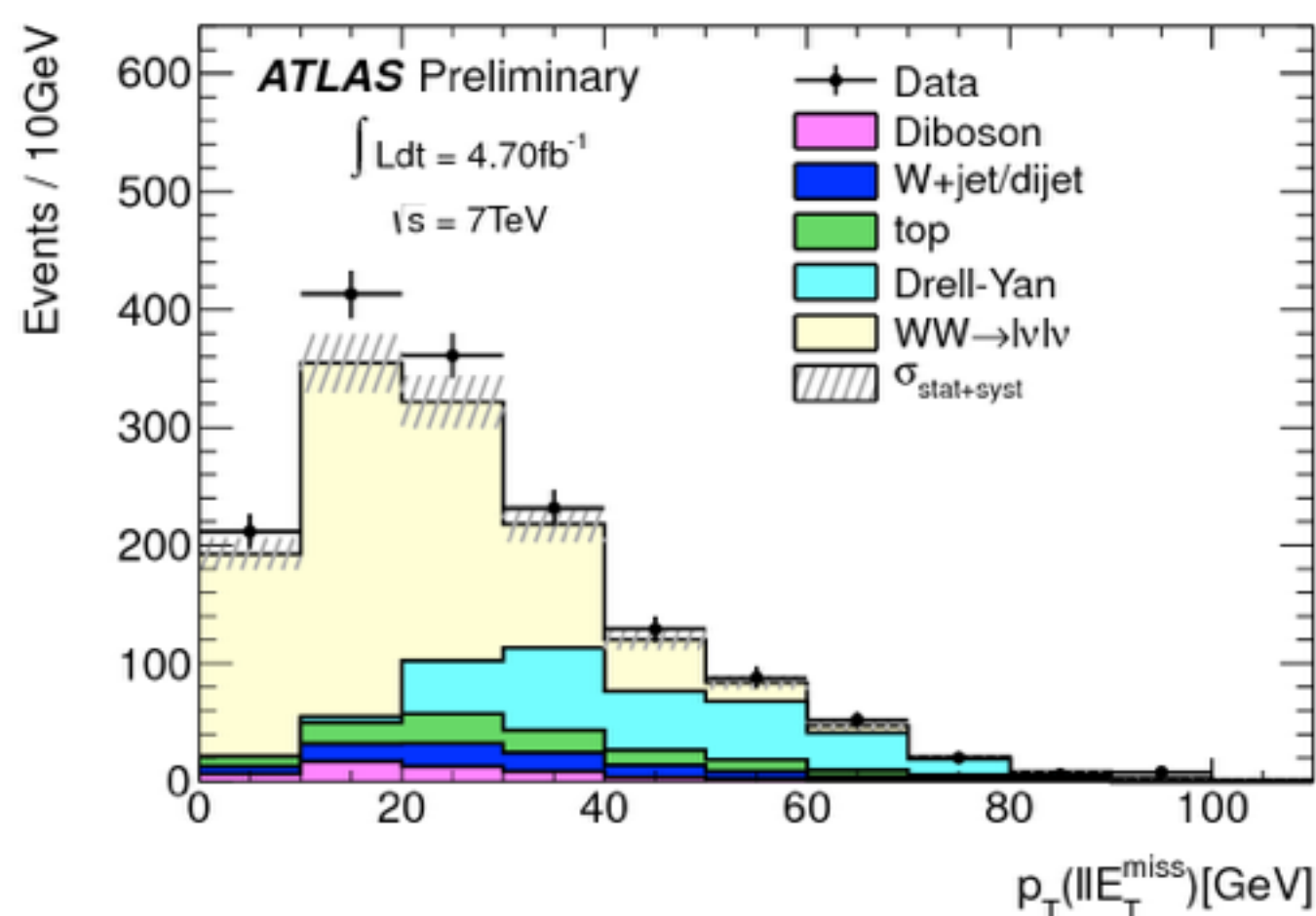
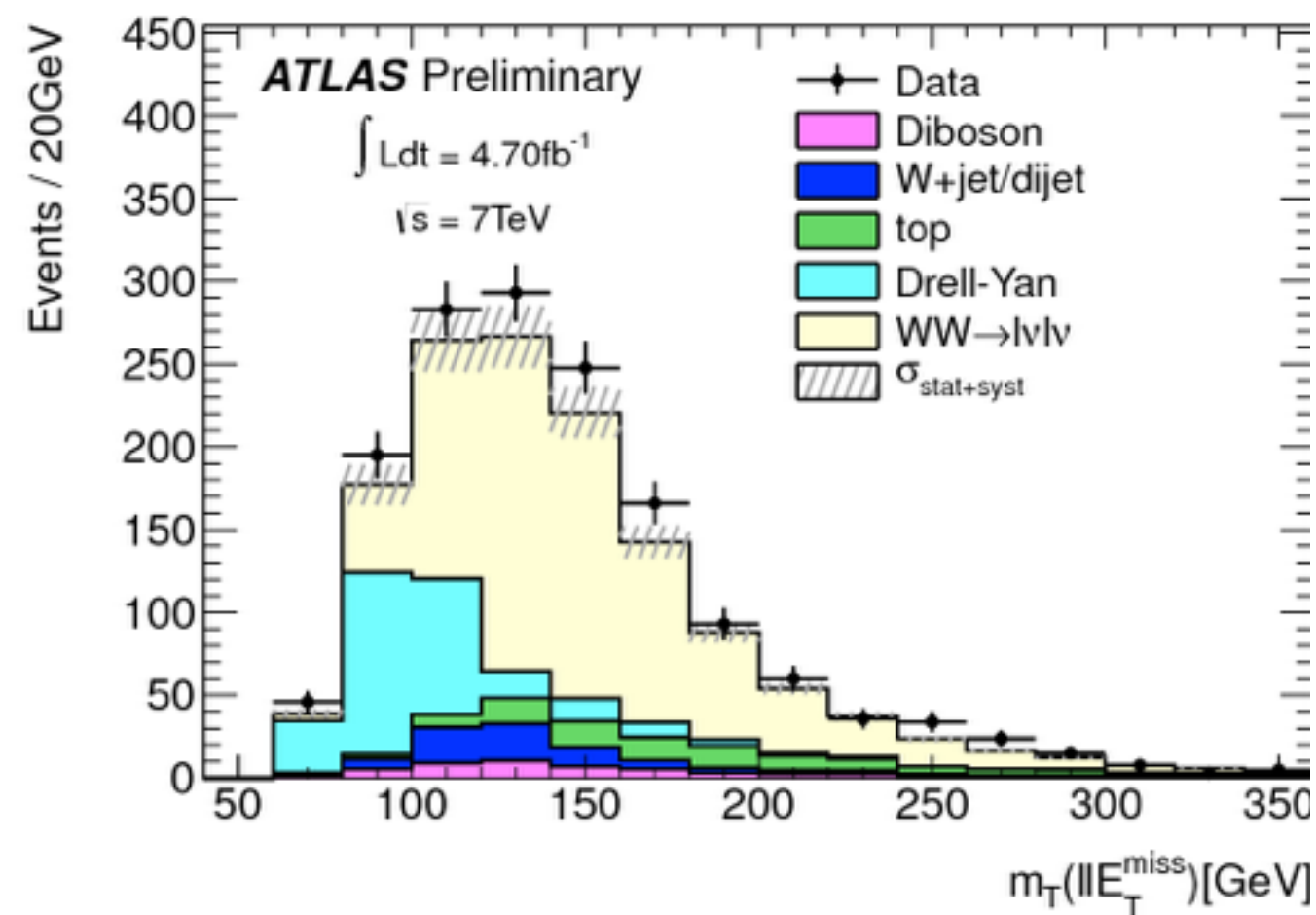
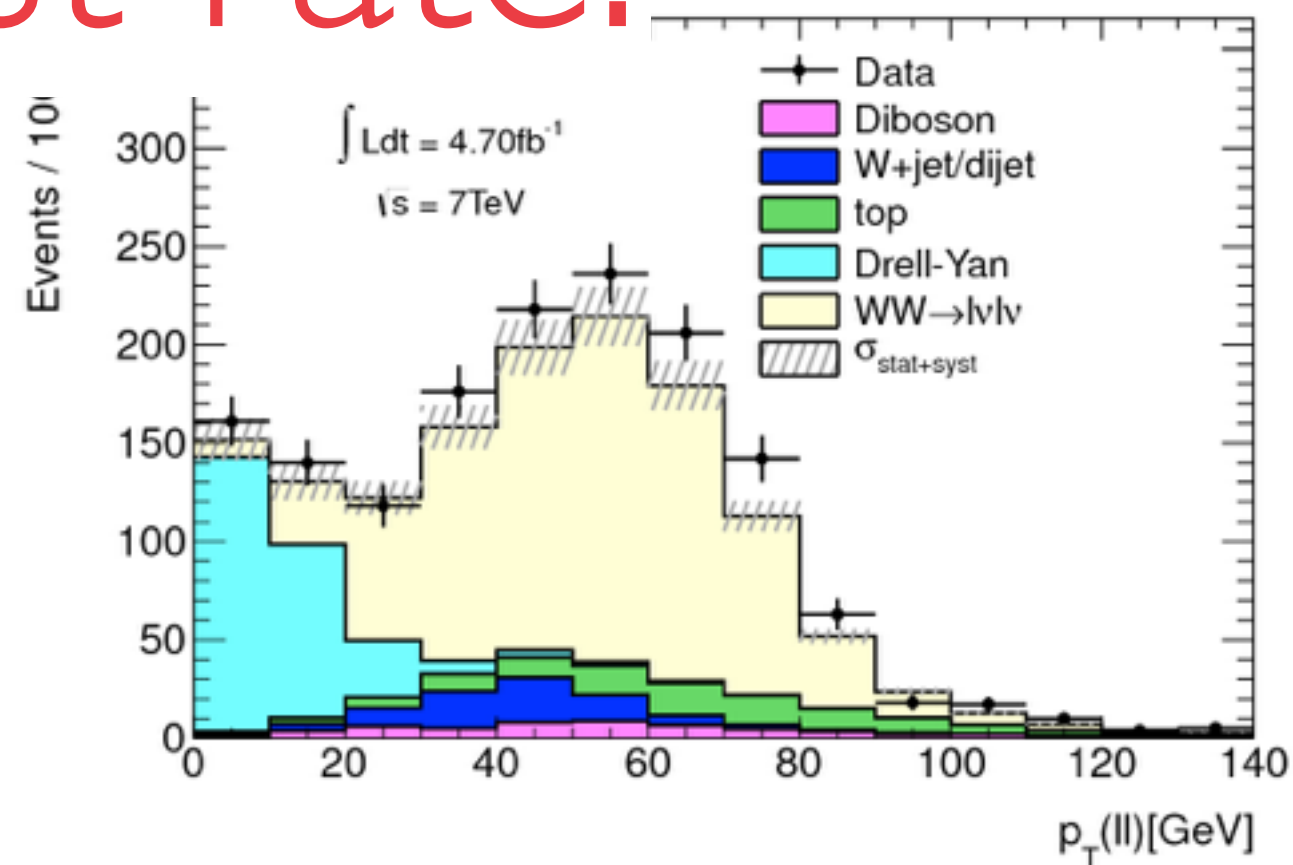
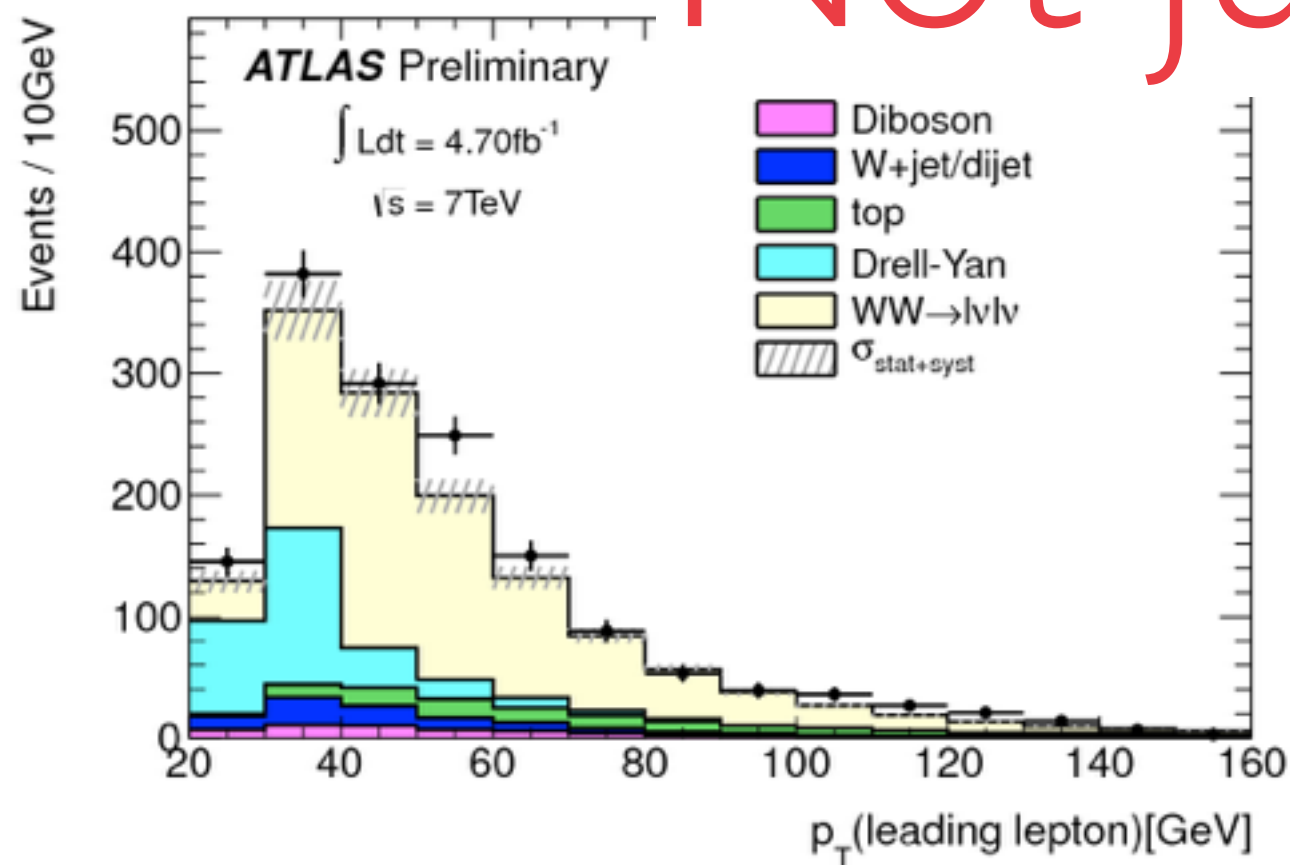
# THERE'S MORE TO IT!

Apr 2014

CMS Preliminary

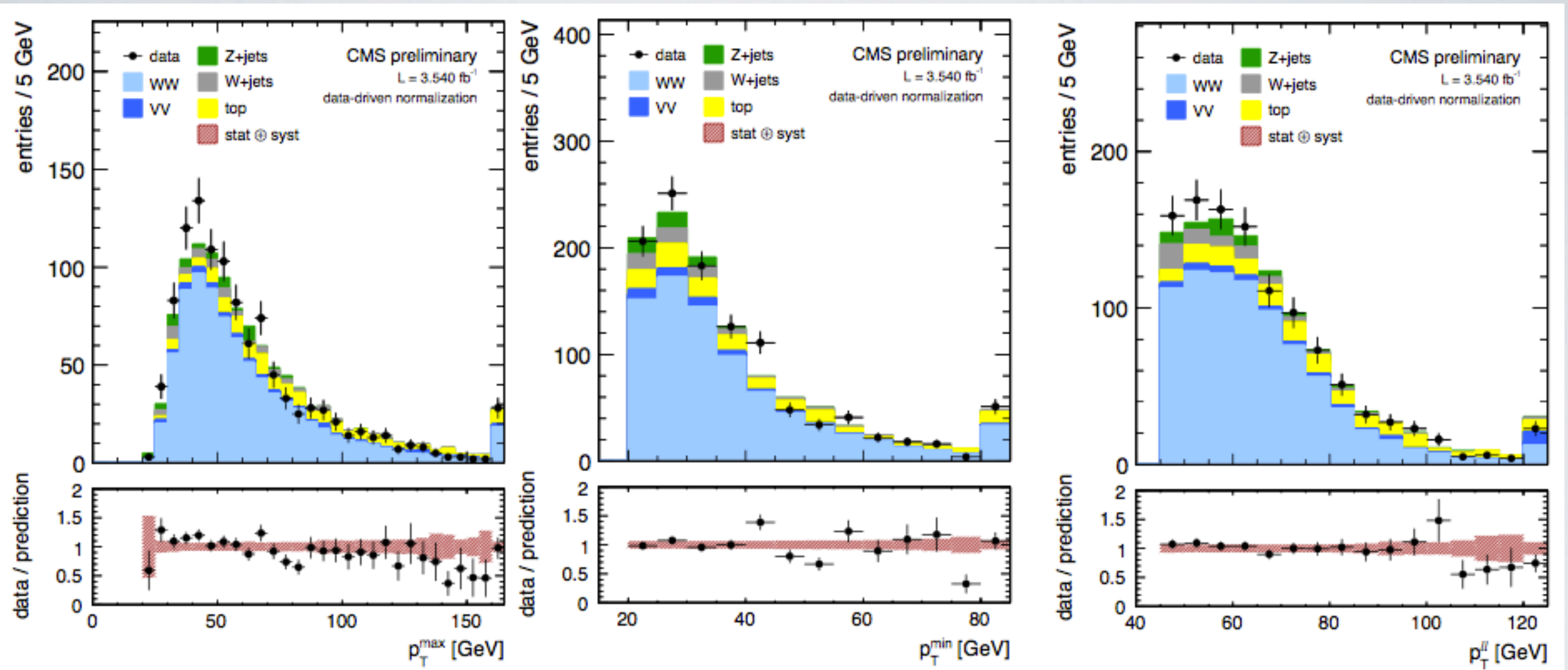


# Not just rate!





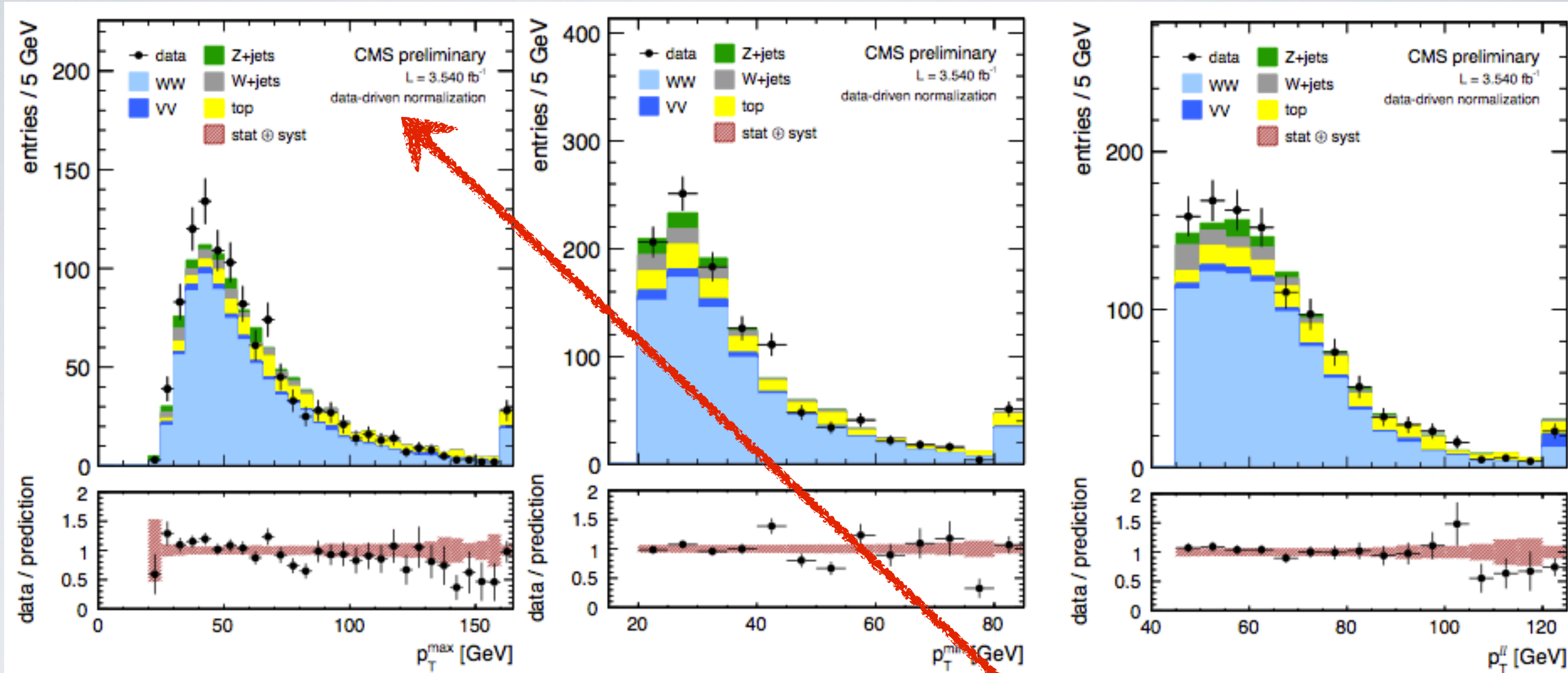
# CMS8



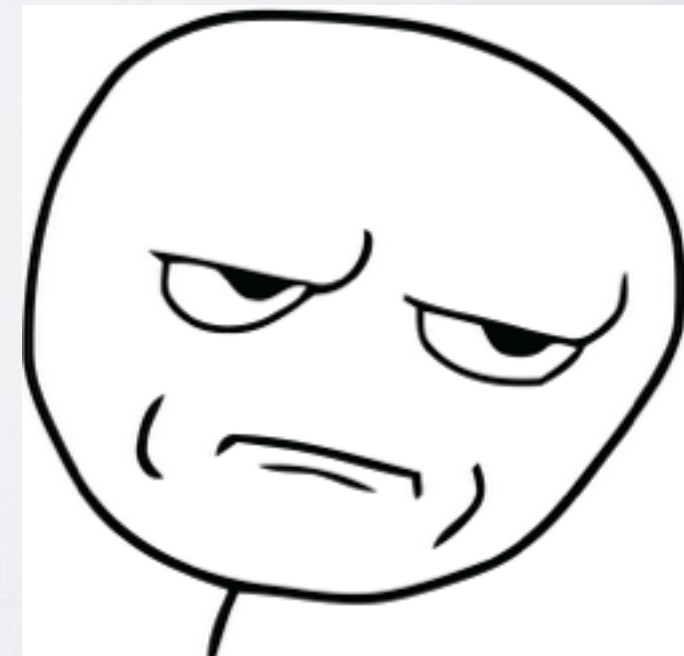
Looks pretty good...



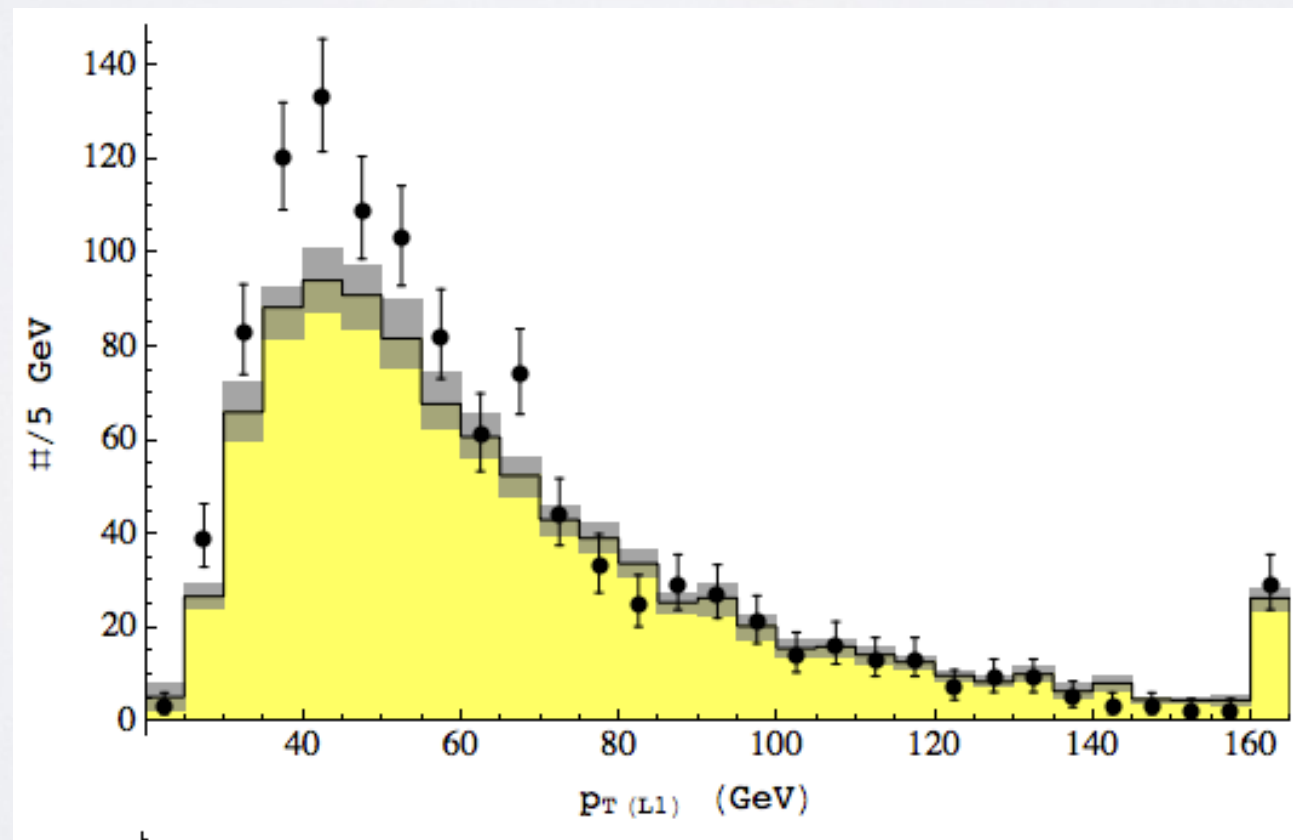
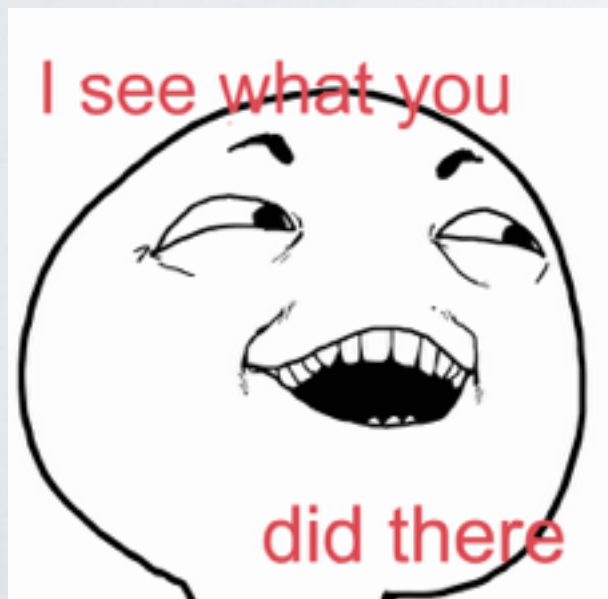
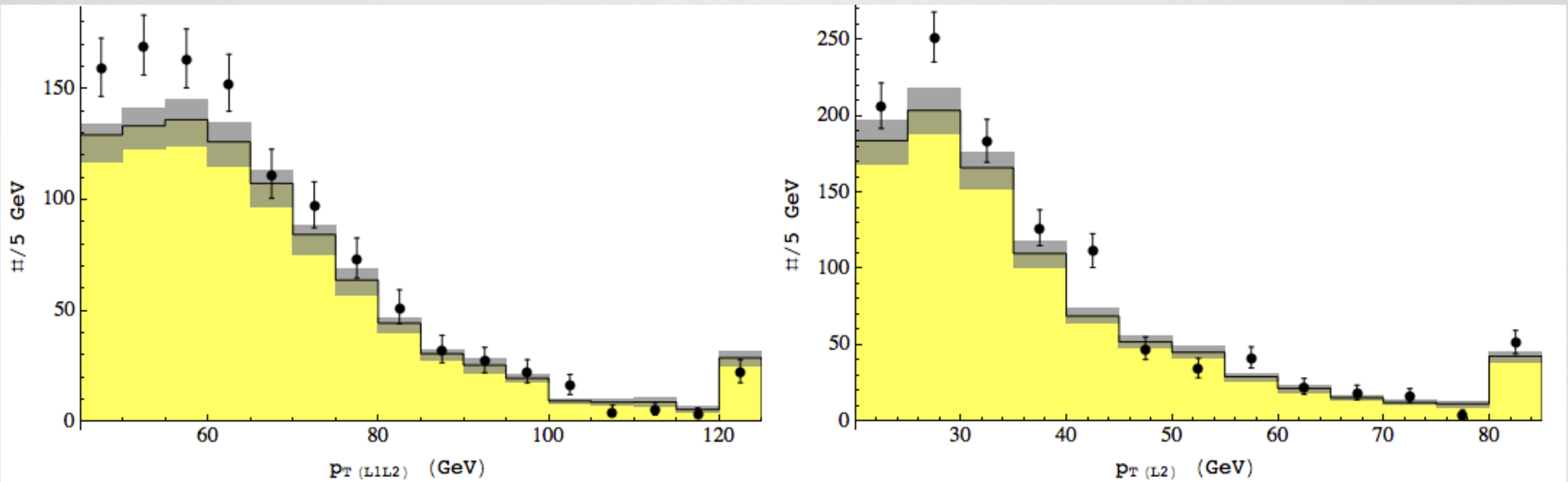
# CMS8



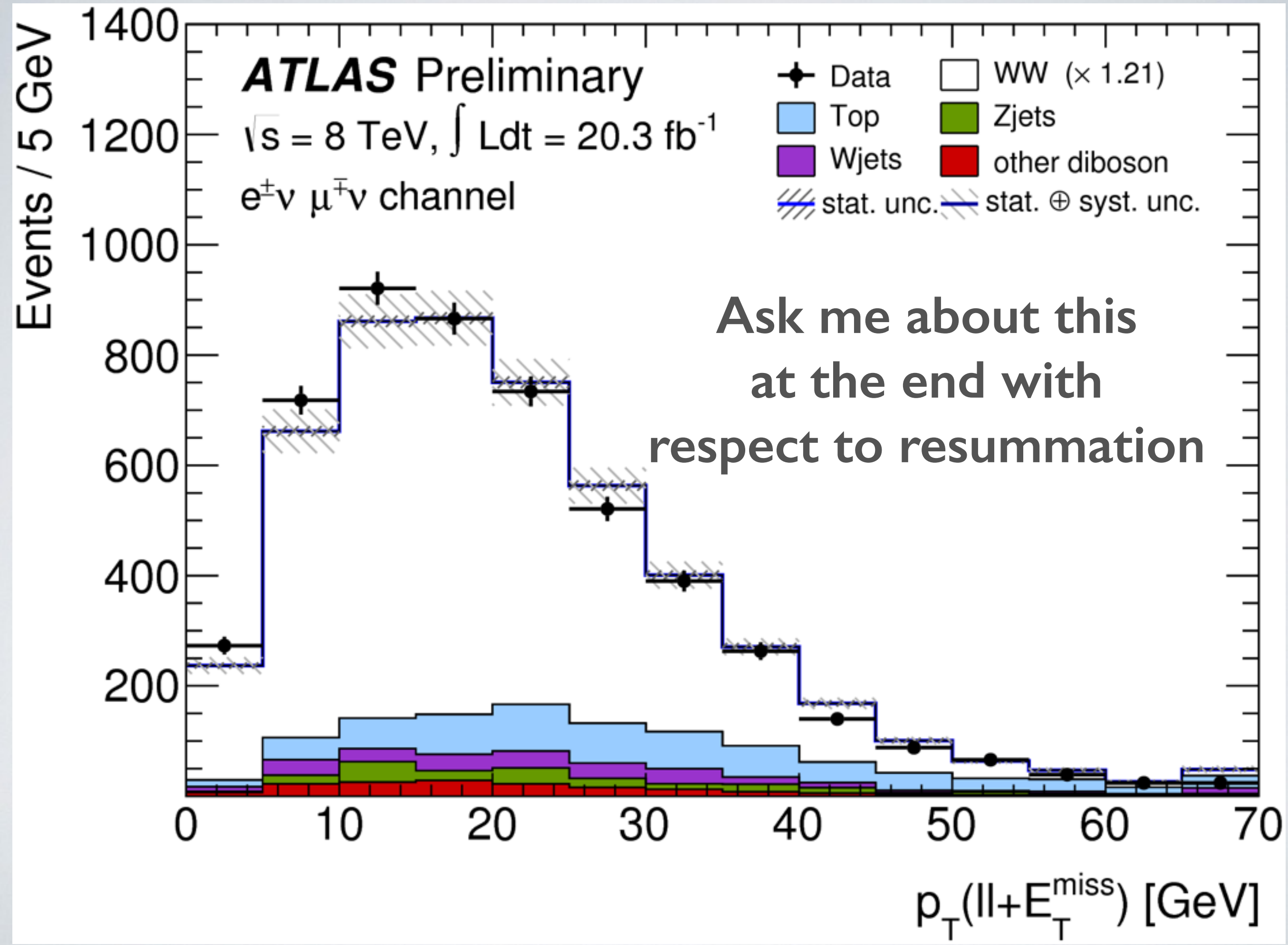
Looks pretty good...



# NO EXTRA NORMALIZATION...







# COULD THERE BE NEW PHYSICS HERE?

- I'm NOT saying there is, in fact I've also worked to explain why the SM could explain this
- I am saying that it's an important test case to understand what could be lurking!

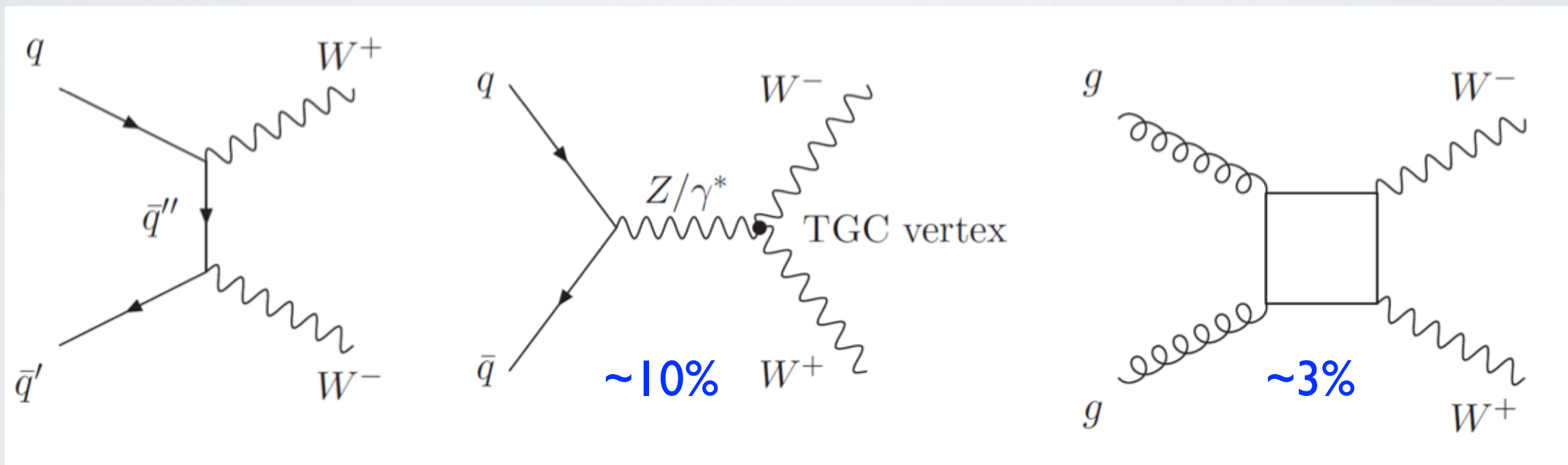


# IF YOU WANT TO EXPLAIN WITH BSM WHAT DO YOU NEED?

- Need to first understand what it MEANS to measure the  $WW$  cross section!

Total  
cross section

$$\sigma_{WW} = \frac{N_{\text{data}} - N_{\text{bkg}}}{C_{WW} \times A_{WW} \times \text{BR} \times \mathcal{L}}$$



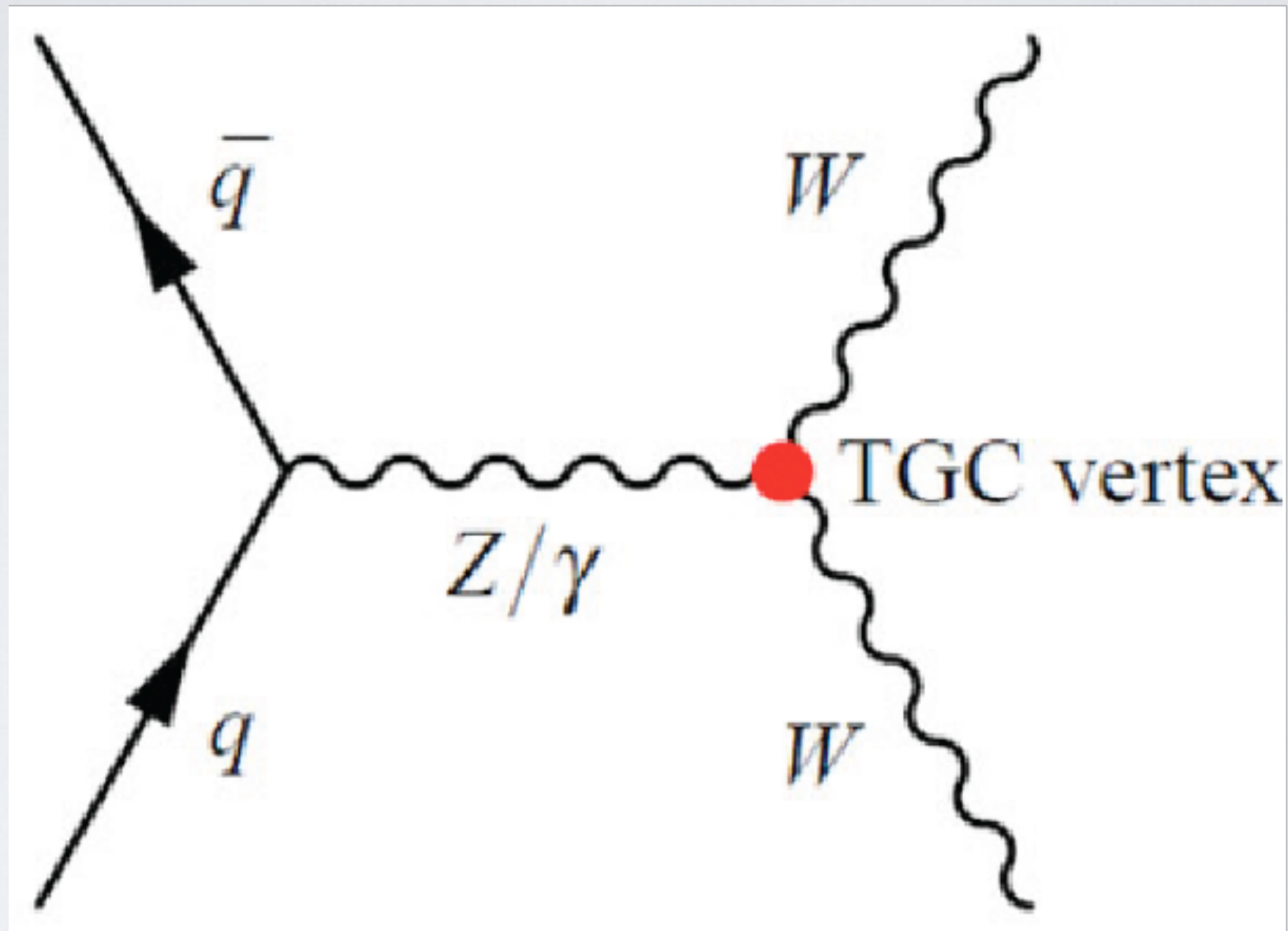
Count opposite sign dileptons + MET in a fiducial region  
with **a jet veto** and a few other requirements

# INGREDIENTS FOR BSM EXPLANATION

- ATLAS and CMS both measure OS dileptons + MET **with** a jet VETO
- Final state needs to be OS leptons+MET with *nothing* else essentially
- Does **NOT** imply there have to be **REAL W's**

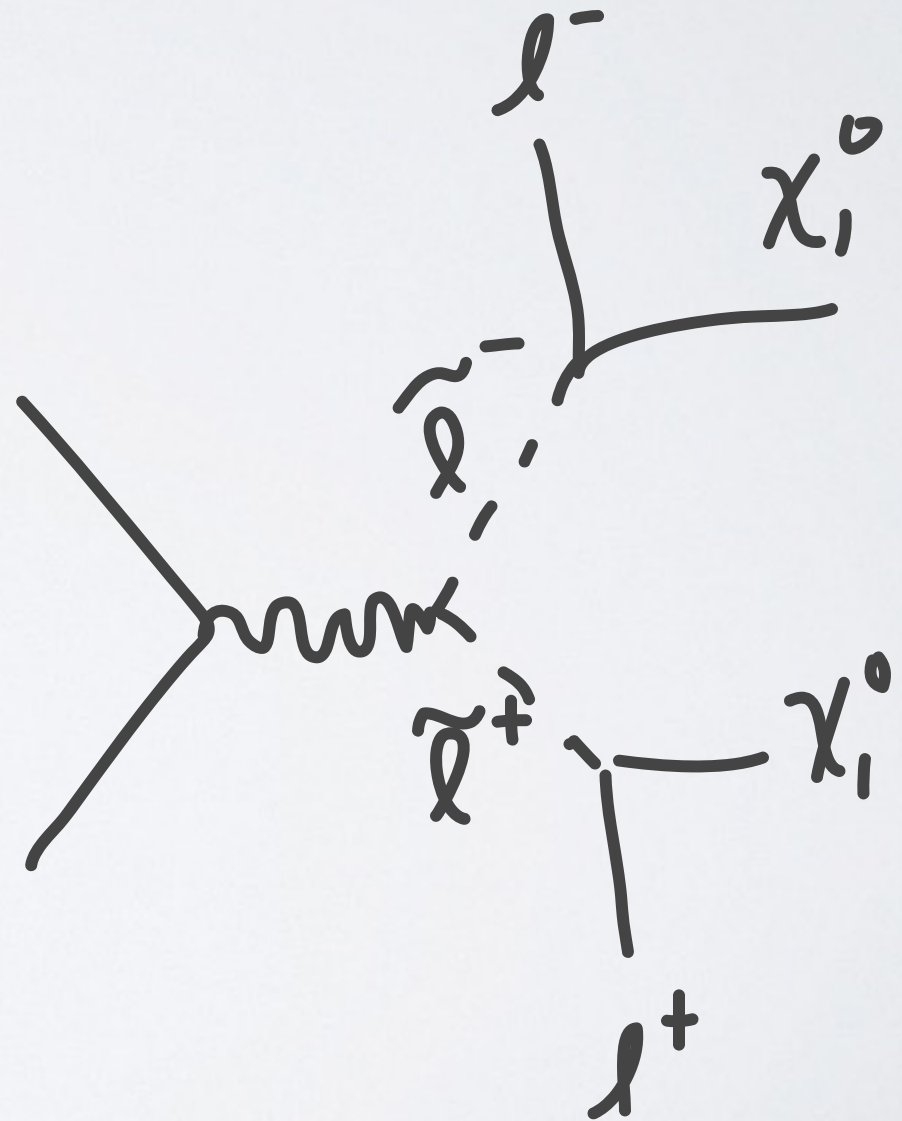
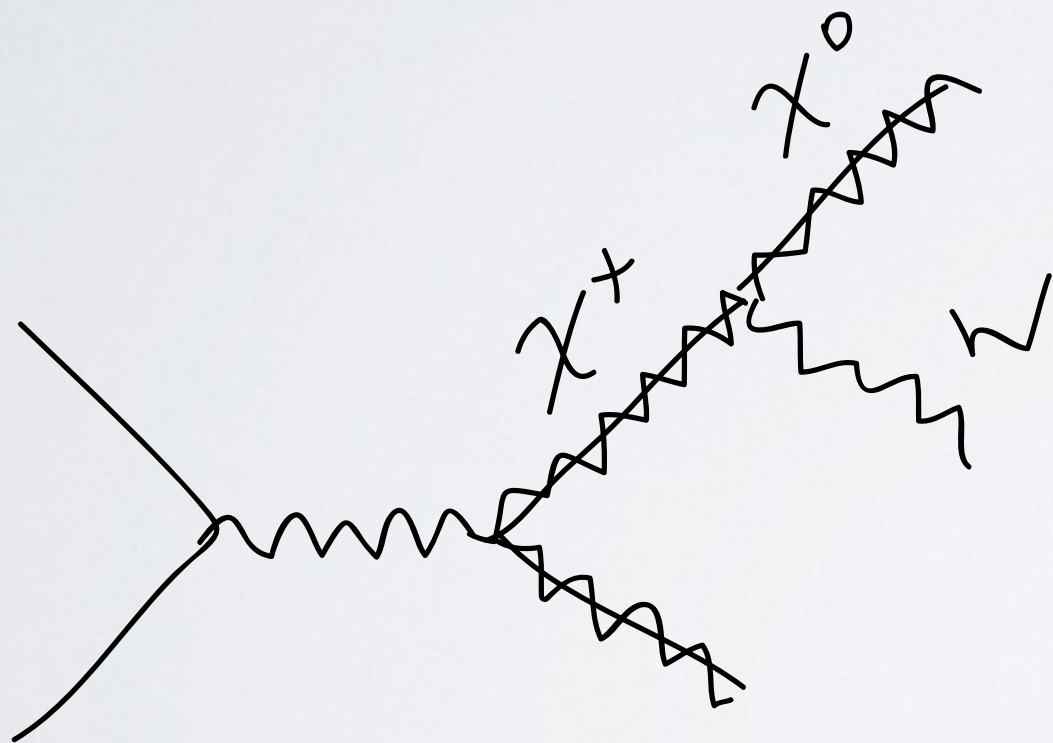


COULD IT BE AN EFT  
EXPLANATION?



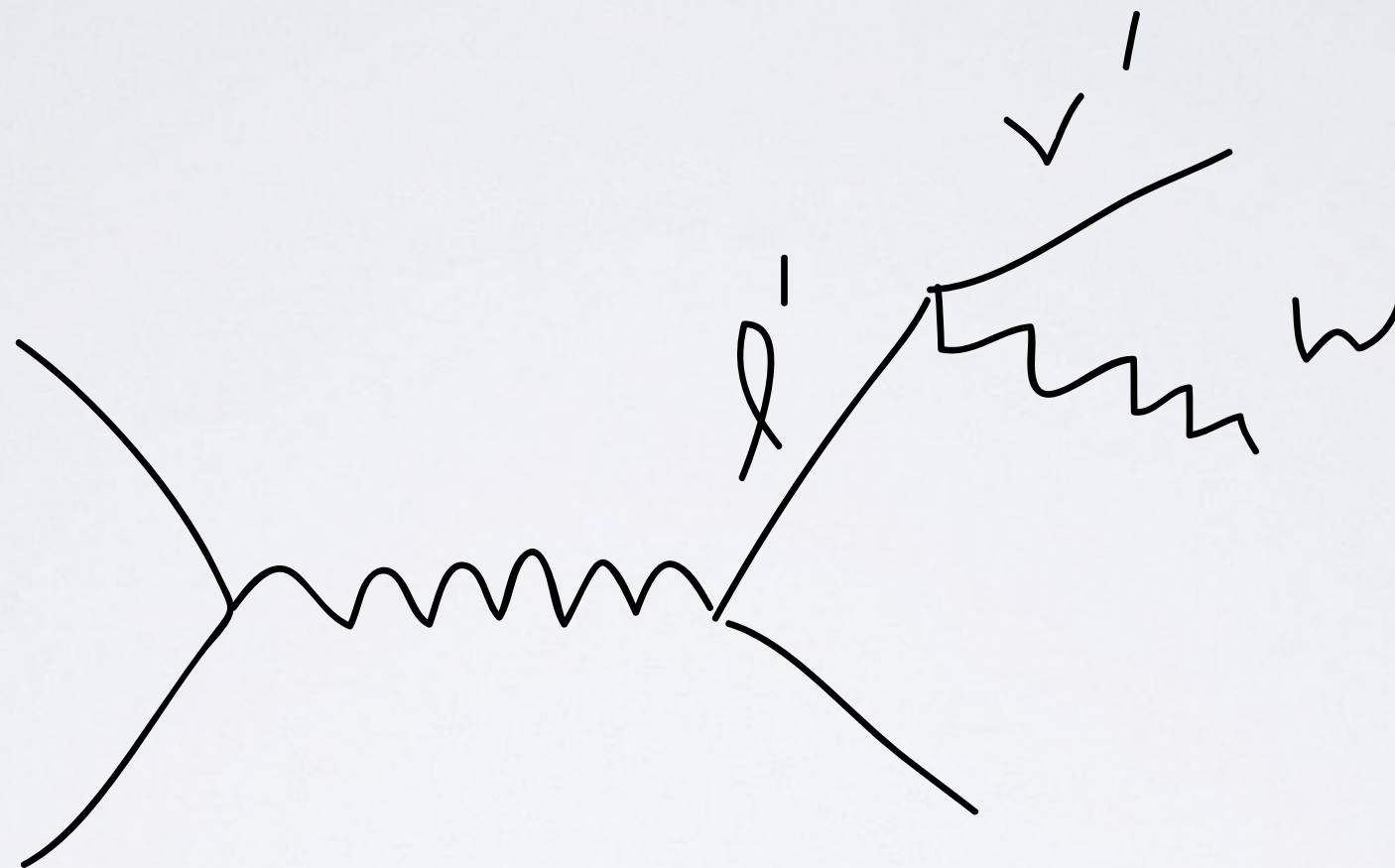
NO! Need to affect the bulk not  
tails of distributions!

# EXAMPLE SUSY TOPOLOGIES FOR “WW”+MET



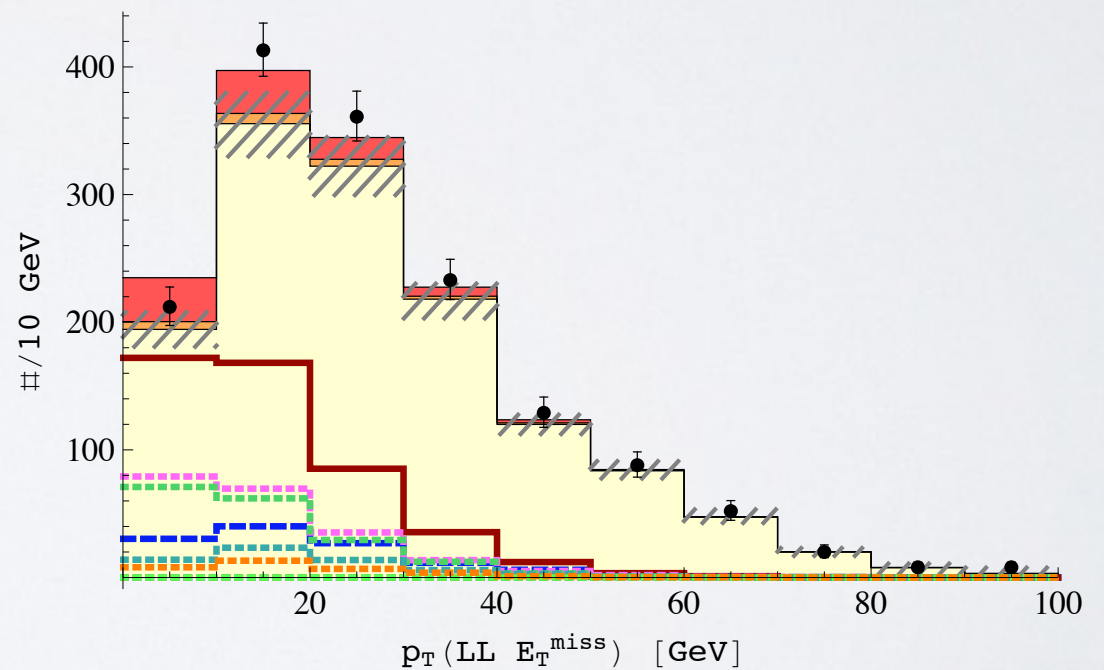
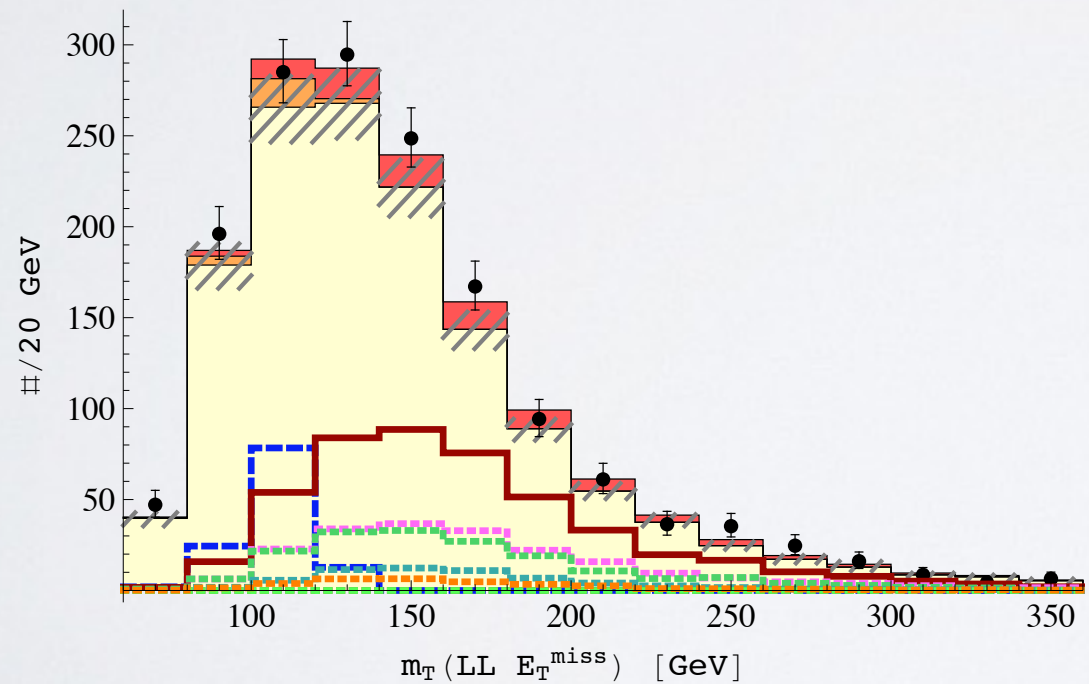
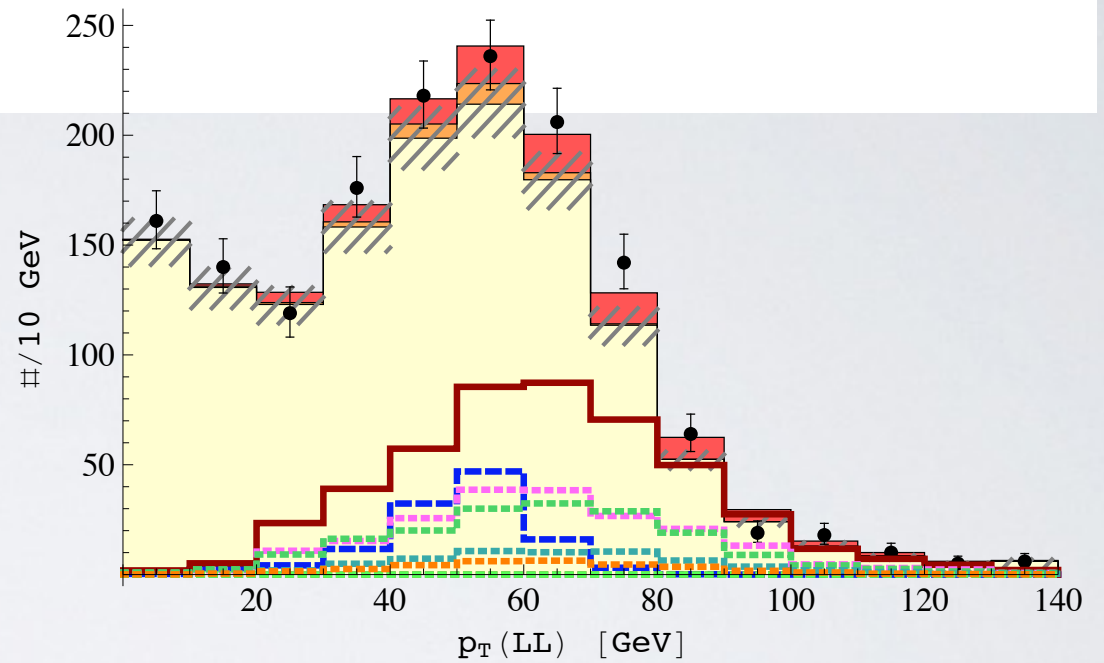
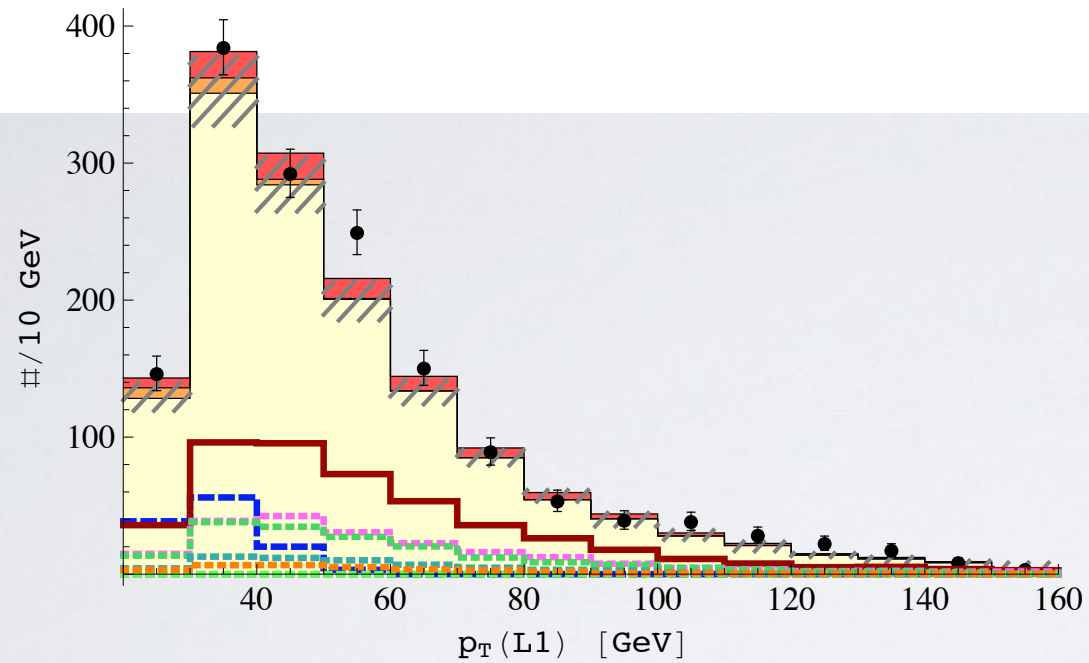
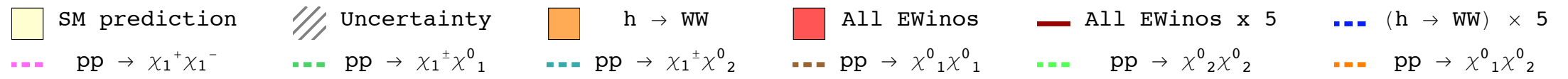


# DON'T LIKE SUSY??



“Heavy Lepton”

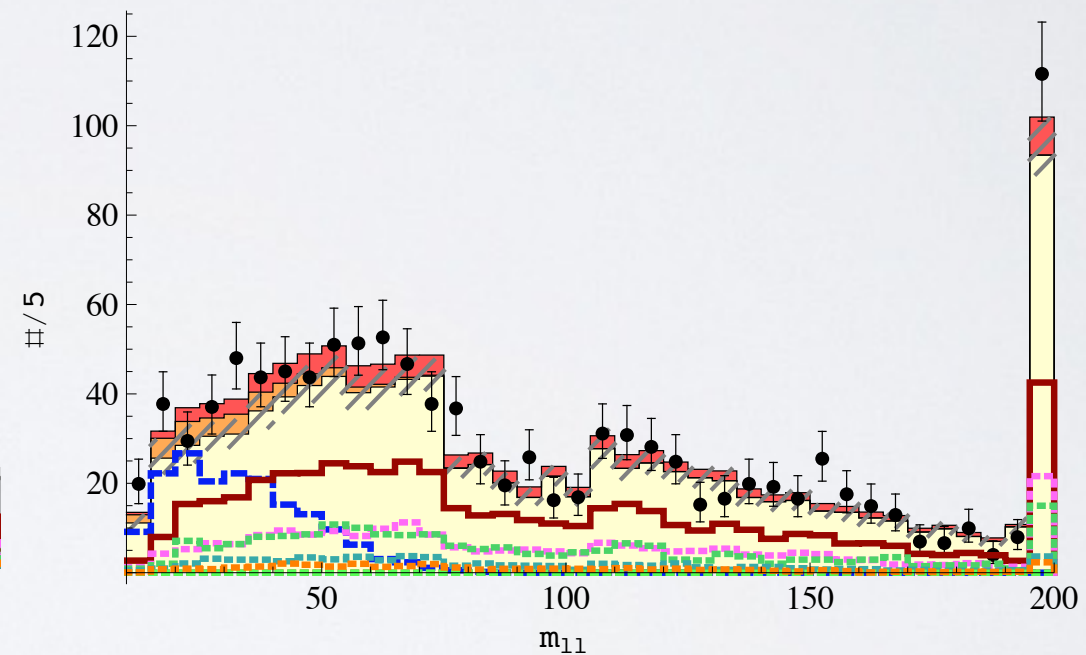
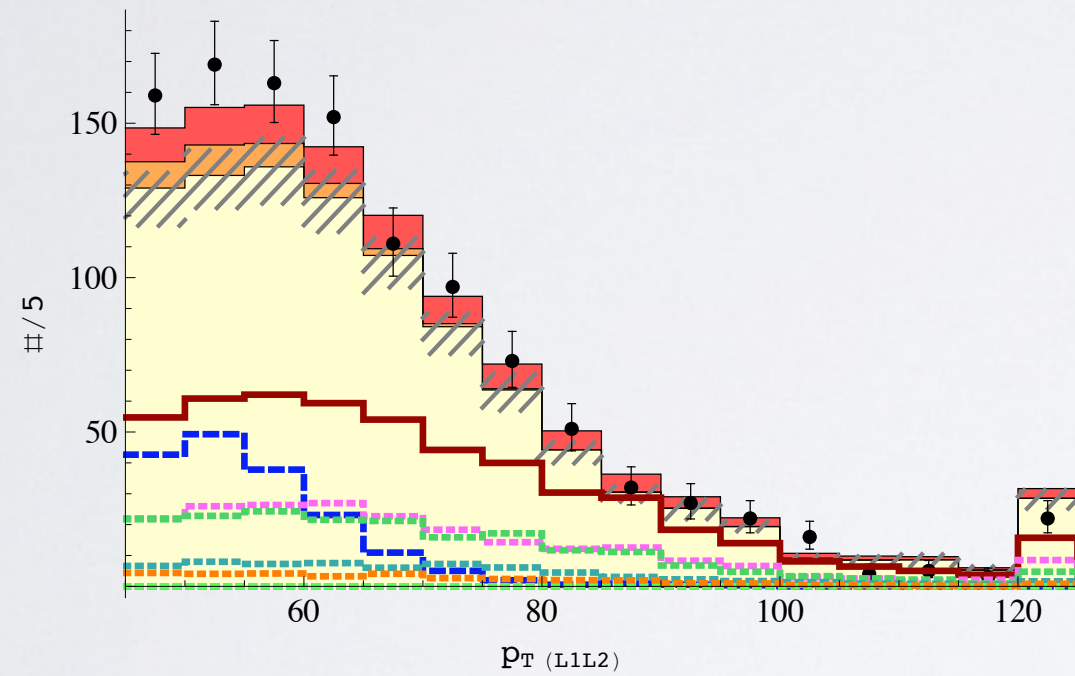
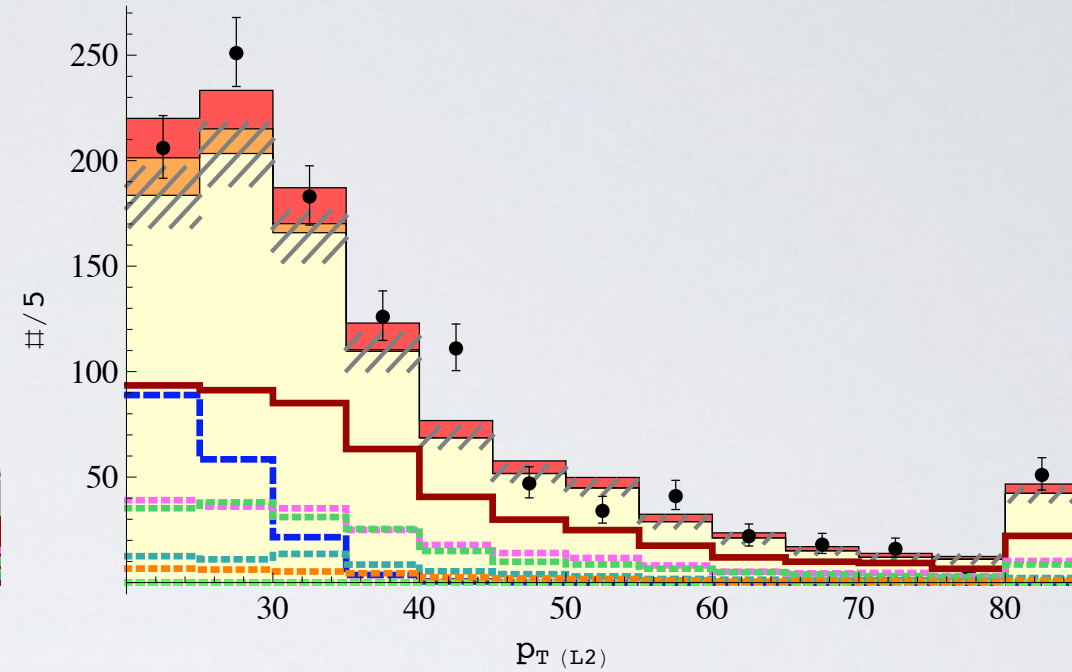
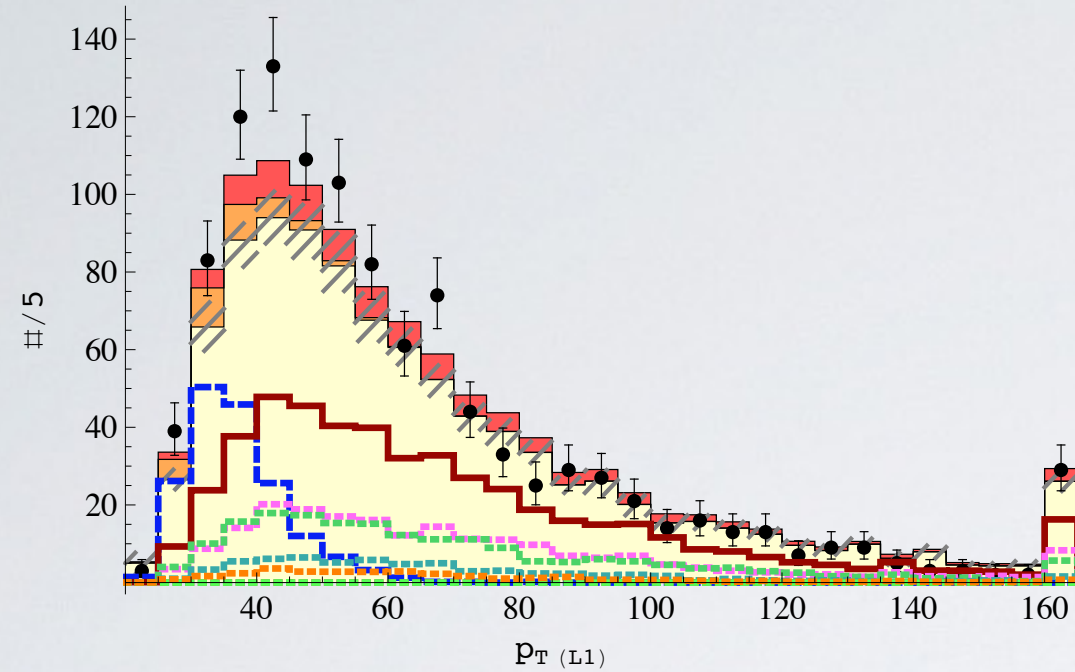
# ATLAS 7



$\chi^2$  cut in **half** compared to SM



# CMS 8



SM p-value .001

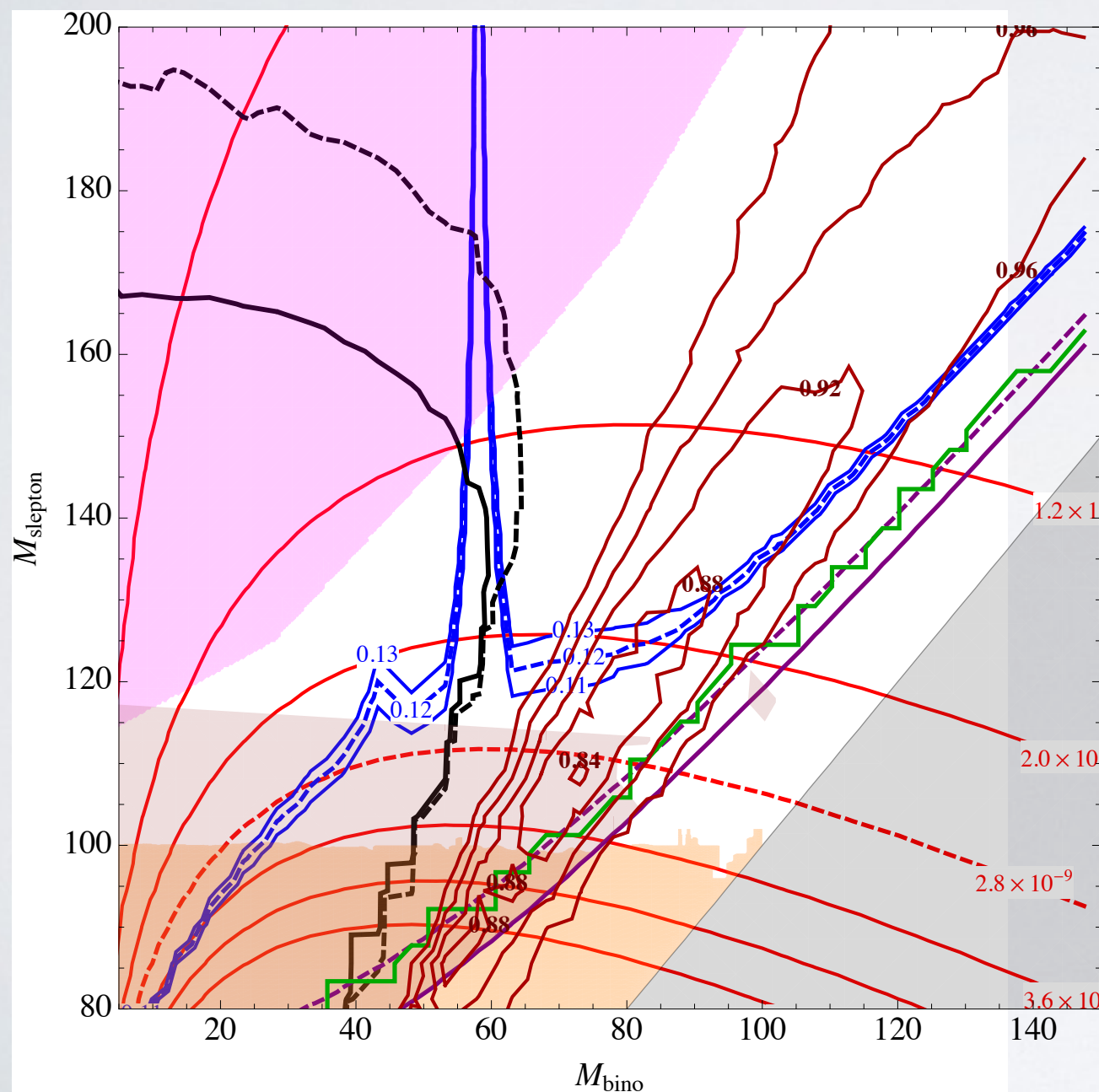
SM+h .1

SM+charginos .3

SM+h+charginos .75

# CAN SOLVE MOST ALL PROBLEMS IN THE WORLD WITH SLEPTONS...

$$pp \rightarrow \tilde{l}^+ \tilde{l}^- \rightarrow l^+ l^- \chi^0 \chi^0$$



(b)  $\tan \beta = 4, \mu = 600 \text{ GeV}$

g-2, DM relic density/  
DD xsec  
WW cross section

Also has implications for  
h to WW, signal and control  
regions are affected differently

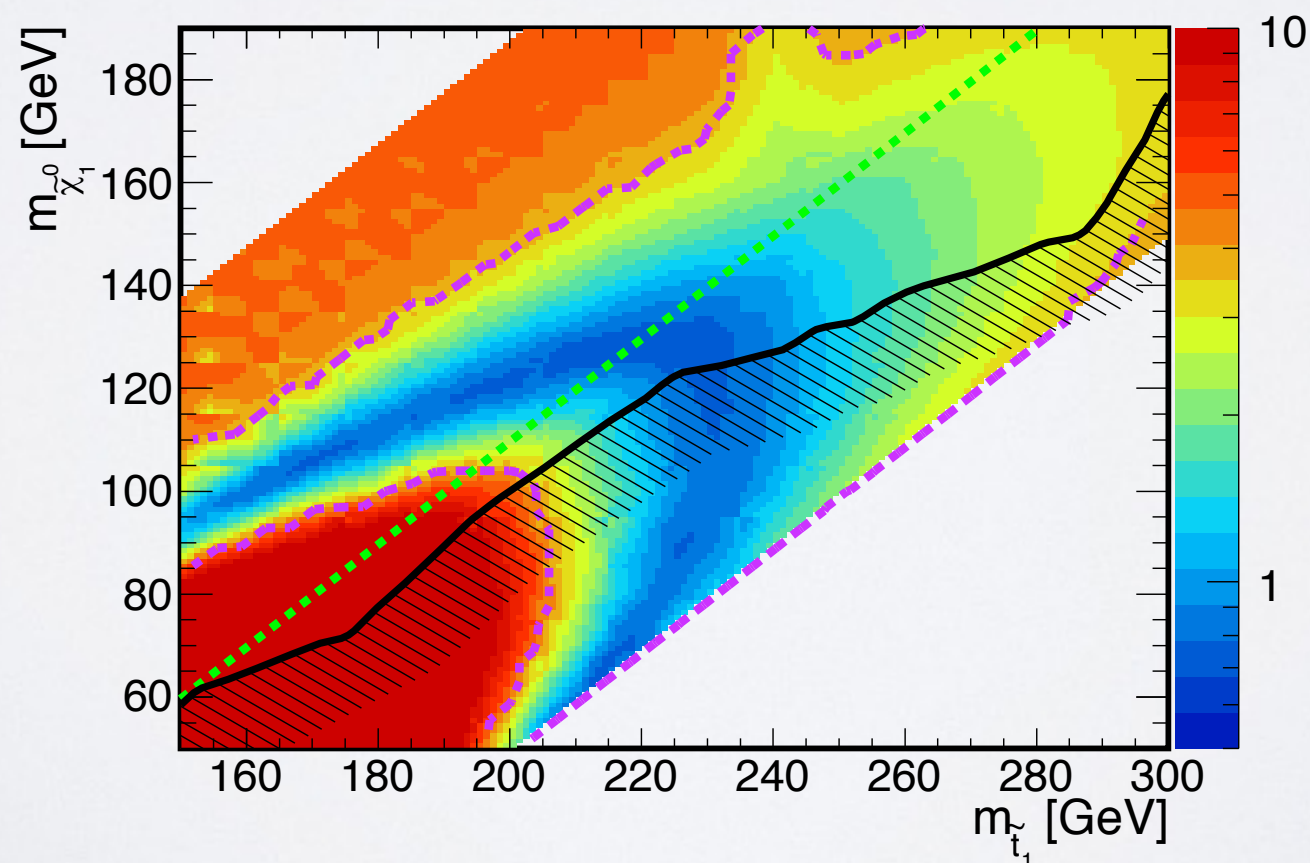
# CHARGINOS FROM STRONG PRODUCTION?

$$\tilde{t}_1 \rightarrow \tilde{\chi}_1^\pm \quad b \rightarrow \tilde{\chi}_1^0 W^{(*)} \quad b \rightarrow \tilde{\chi}_1^0 \ell \nu \quad b$$

Squeeze the b's and you  
get WW production

Rolbiecki and Sakurai  
1303.5696

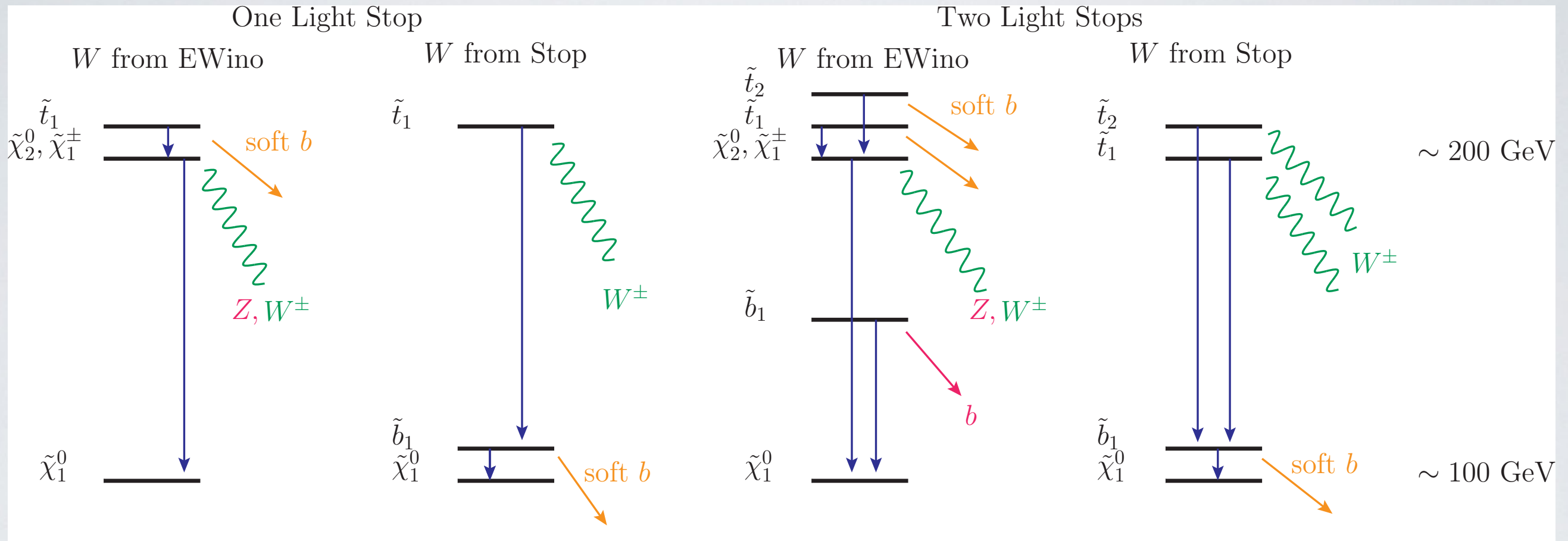
$\chi^2$ : [ATLAS7, CMS7, CMS8]





# MANY MORE POSSIBILITIES

D. Curtin, PM, P.Tien (1406.0848)



YOU CAN HAVE COMPLETELY  
NATURAL SUSY!!!!

# NEW PHYSICS IN SM MEASUREMENTS

- BSM scale doesn't have to be high, it can be contaminating your measurements
- EFT approach is pointless to describe this physics
  - Theorist handing you an operator is dangerous...
- Exotics and SUSY groups won't find this without better SM theory and measurement!

# CAN WE DISTINGUISH BSM FROM SM? - DISCUSSION

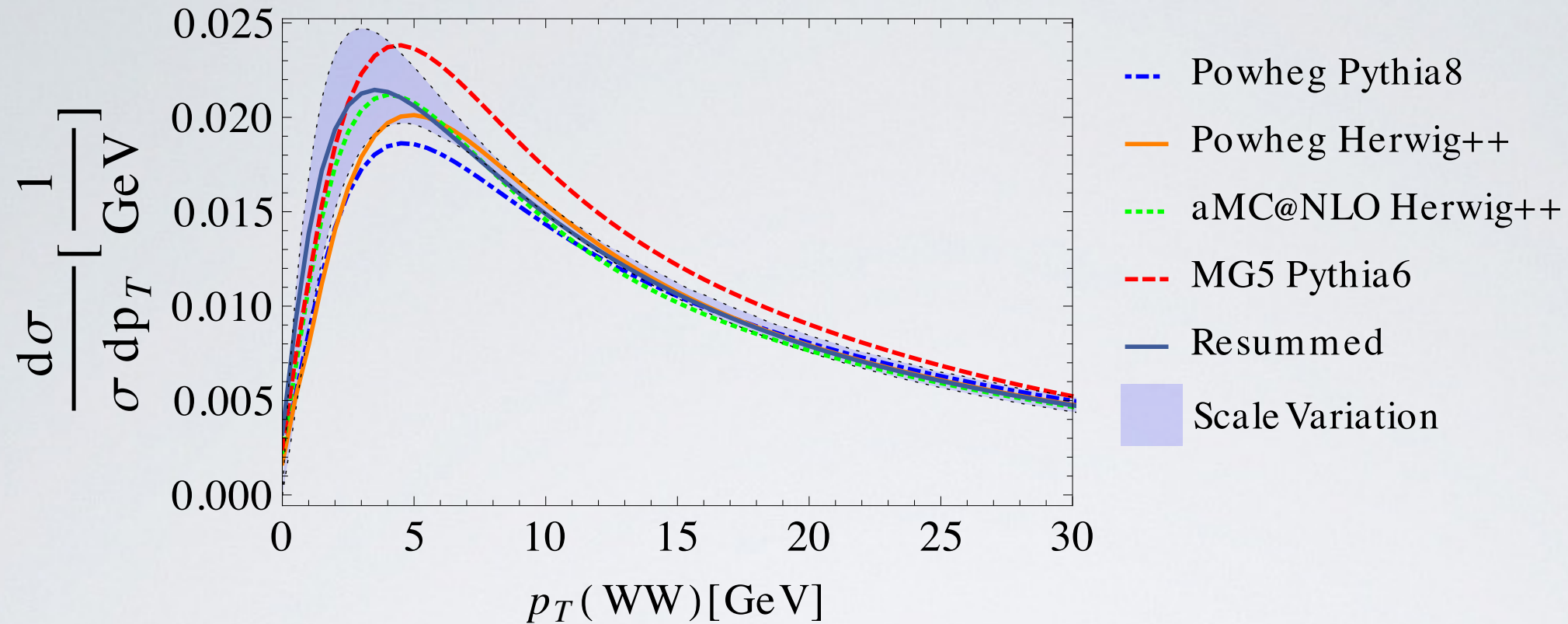
- Lots of SM theory explanations have also recently come up
  - Fixed order cross sections
  - Jet veto resummation
  - Pt resummation
- What does it all come down to?

$\sigma_{inc}$

$\epsilon_{veto}$

**Suggestions, cross section as function of veto  
b-jet veto, comparison across channels!!**





MC + Parton Shower	Corrections (%)
Powheg+Pythia8	$6.5^{+5.0}_{-3.0}$
Powheg+Herwig++	$3.8^{+4.3}_{-2.5}$
aMC@NLO+Herwig++	$3.1^{+5.0}_{-3.0}$
MADGRAPH LO+Pythia6	$-9.6^{+4.4}_{-2.7}$

Table 4: Percentage differences for  $\sigma_{\text{Fid}}$  of reweighted theory predictions compared to MCs+Parton Showers at 8 TeV.

